2.0 DESCRIPTION OF STUDY AREA

This chapter provides a descriptive summary of the physical setting and history of the Estero Bay and Watershed.

2.1 Topography

The Estero Bay Watershed is relatively flat and ranges in elevation from sea level to a maximum of 50 feet NGVD in the eastern portion of Lee County. Elevations gradually increase away from the coast and the Caloosahatchee River and peak in southeastern Lee County. The Cow Creek and Hendry Creek basins are low and do not exceed 5 feet NGVD throughout the basins, while elevations in basins farther south increase closer to the coast.

Elevations in the Estero Bay Watershed are lowest along the coastline and areas associated with the Caloosahatchee Valley, and increase in a northeasterly direction. Elevations increase from 0 feet NGVD along the coastline and river and stream channels to over 40 feet in the far northeastern portion of the watershed (Plate 2-1).

The lower elevations are associated with the Southwestern Slope Physiographic Province and increase from 0 to 15 NGVD over more than half the watershed, including the Fahkahatchee Strand and Lake Trafford in the western portion of the watershed. The higher elevations in the most easterly portion of the watershed are associated with the Immokalee Rise, and increase relatively steeply from 15 feet to over 40 feet in elevation. The Immokalee Rise also separates the drainage to the Everglades from the west coastal areas in this part of the peninsula.

2.2 Geology

The Estero Bay Watershed occurs within the Florida Peninsula sedimentary province and is dominated by nonclastic sediments, which are primarily carbonates and anhydrites, chemically or biologically produced (Drew and Schomer, 1984). Changing Pleistocene shorelines and alternation of marine and freshwater influence resulted in various Pleistocene deposits, including quartz sand, shell beds, limestone, and marl (Klein et al., 1964). Surficial geology in the watershed is composed primarily of undifferentiated shell beds, while smaller areas of organic matter and clay associated with lagoonal deposits occur along the coast and limestone and marls occur along the western edges of the watershed (Plate 2-2). The geomorphology and geohydrology of the watershed are presented in the following sections.

2.2.1 Geomorphology

In the Estero Bay Watershed, the Pleistocene strata are composed of marine terraces and sands, namely the Caloosahatchee and Fort Thompson Formations. The lack of core data and difficulty of distinguishing the Anastasia Formation from the Fort Thomson Formation make it difficult to verify that the Anastasia Formation may underlie a major portion of the watershed.

The most ancient of the Pleistocene rock layers in south Florida is the Caloosahatchee Formation, which is primarily a grayish-green, silty, sandy, shell marl with imbedded layers and lenses of sand, silt, clay, and marl. The formation occurs only in the eastern part of the watershed, ranging in thickness from a few meters to greater than 50 feet near the western edge of Lake Okeechobee. The Caloosahatchee Formation is typically overlain by the Fort Thompson Formation of freshwater marl and limestone, which alternate with beds of marine shell marl.

The Fort Thomson Formation is overlain by the Coffee Mill Hammock, a marine shell bed, which was deposited in a shallow semi-restricted, high-salinity bay similar to present-day Florida Bay (Dubar, 1974; Jacob and Waltz, 1980). The tops of the freshwater beds have been hardened into brittle limestone, but are perforated by solution holes filled with marine shells from succeeding strata. The Fort Thompson Formation is of special importance because it forms a large part of the Biscayne Aquifer, the sole drinking water source for the southeast coast.

The Pleistocene terraces and shorelines identified in the watershed, from the lowest in elevation to the highest, are Silver Bluff, Pamlico, Talbot, Penholoway, and Wicomico Terraces. The terraces are composed of quartz sand and lie discontinuously upon the Fort Thompson, Caloosahatchee, and Tamiami formations.

The land within the Estero River Watershed is a mixture of uplands and wetlands which display very little topographic relief. The basin lies within the Southwestern Slope region of the Southwestern Flatwoods physiographic province. The slope most likely originated as a marine terrace during periods of higher sea level and varies in elevation from a high of 25 feet to sea level. The surface consists of shells, marls, and organic material underlain by limestone.

The largely low, flat district developed on rocks and sediments that range mainly from Miocene to Pleistocene in age. The landscapes include low plateaus and ridges, flatwoods, prairies, rockland/marl plains, and a variety of coastal features. Surficial materials are dominantly sand (often with relatively clayey substrata), limestone, and organic deposits. Where quartz sand has been continuously available due to Miocene sediments of the mid-peninsular west coast, seaward migration of shorelines explains the broad succession of relict beach ridges and barriers that characterize the protuberant part of the peninsular Gulf coast between Anclote Key and Cape Romano. The sands which moved southeast from both east and west coasts during Pamlico times did not enter the Everglades, but built the sandy Immokalee Rise and Atlantic Coastal Ridge to the east.

The coastal areas of the Estero Bay Watershed are characteristic of coastal peninsular Florida between Anclote and Cape Romano. The re-entrant physiography is a result of offshore profile, substrate composition, and rising sea level. Offshore bottom topography decreases in steepness toward the south of the watershed. Near shore substrates in the re-entrant sections are more limey than sandy; limestone is not a good source of building barrier beaches and islands. Coastlines are sandy, have conspicuous relict coastline features, and the five-fathom isobath lies approximately 5 miles offshore. These contrast sharply with the coastal areas north of Anclote and south of Cape Romano which are marshy, have obscured relict coastline features, and the five-fathom isobath is 20 to 30 miles offshore.

In general, the ridges of the central or mid-peninsular zone are above the piezometric surface, but the broad valley floors are below it. Broad shallow lakes are common on the valley floors and smaller deep lakes, apparently of rather complex geomorphic history, occur on the ridges.

White (1970) describes the geology of the southwestern portion of the Florida Peninsula. The Estero Bay Watershed included three physiographic regions of south peninsular Florida:

- Caloosahatchee Valley,
- Southwestern Slope, and
- Immokalee Rise.

The Immokalee Rise is an elevated, flat area of predominantly sandy soils. It lies north of the Big Cypress, west of the Everglades, and south of the Caloosahatchee Valley in southwest Florida. Like the Atlantic Coastal Ridge south of West Palm Beach, it is a southerly extension of Pamlico marine sands deposited from more northern portions of the peninsula. Unlike the Atlantic Coastal Ridge, however, the Immokalee Rise exhibits few relicts of Pamlico shoreline features. It appears to have formed as a sub-marine shoal that extended southward from a mainland cape at the south end of the Desoto Plain, similar to the present off-cape shoal extending southward from Cape Romano. Fahkahatchee and Ocaloacoochee Sloughs appear to be emergent relicts of Pamlico tidal passages through this shoal. Relict coastal features that may have formed during emergence of the shoal from the Pamlico sea are very weakly developed, likely as a result of prevailing low energy conditions.

As in other areas where sand overlies limestone, a line of lakes has developed along the edge of the sand-covered area and the sandy Immokalee Rise is ringed with small solution lakes. These peripheral lakes are so characteristic that the edge of the sand covered area can be delineated by drawing a line on the map and connecting the lakes.

The Caloosahatchee Valley slopes very gradually upward to the north of the Caloosahatchee river to the Desoto Plain, a very flat terrace extending down from the Polk Uplands. The Caloosahatchee Incline, like the Immokalee Rise, formed as an erosional sub-marine terrace of the Pamlico shoreline.

As the Pamlico sea level dropped, the Immokalee rise emerged as a sloping sand shoal south of the Caloosahatchee Valley. The Southwestern slope is a northwest-southeast trending area gently tilted toward the Gulf of Mexico. Toward the south, a drainage pattern perpendicular to the coast is evident in the sloughs and strand vegetation. The substrates associated with the Southwestern Slope are thin sands over Tamiami Limestone. Northward, the sands are deeper and vegetation becomes dominated by pinelands.

2.2.2 Geohydrology

The sequence of rocks underlying the Estero Bay Watershed can be grouped hydrogeologically into aquifers and confining zones. The basic criteria for including a section of rock strata within a particular aquifer designation are substantial vertical and lateral hydraulic continuity within the rock strata (SFWMD, 1982).

The five major aquifers or producing zones in the area are listed below. They are the:

- Surficial Aquifer,
- Sandstone Aquifer,
- Mid-Hawthorn Aquifer,
- Lower Hawthorn/Tampa producing zone, and
- Suwannee Aquifer.

The lower Hawthorn/Tampa producing zone is actually part of the Floridan Aquifer. There are also four basic types of aquifers: unconfined, confined, semi-confined, and semi-unconfined. Unconfined aquifers are composed of permeable substrates which may be partially or completely saturated with water, while a confined aquifer is completely saturated and is bounded at the top and bottom by relatively impermeable beds. Semi-confined or leaky aquifers are bounded above and below by low permeability beds. Water can move vertically through semi-confined beds. The Sandstone, mid-Hawthorn, and the individual aquifers within the Floridan Aquifer are generally termed semi-confined aquifers. The Surficial Aquifer has properties of the unconfined, semi-confined, and semi-unconfined aquifer types.

The Surficial Aquifer occurs within sediments of the Tamiami Formation and the undifferentiated deposits. The thickness of the Surficial Aquifer varies between 25 and 50 feet in central Lee County and thickens west of Cape Coral and in the southeastern part of Lee County. It is very thin just south of the Caloosahatchee River in the northeast and central portions of Lee County.

A Coral Reef Aquifer extends into southern Lee County from Collier County at shallow depths. In areas where the underlying Hawthorn confining zone is thin or absent the Surficial Aquifer is in direct hydraulic connection with the Sandstone Aquifer. The upper Hawthorn confining zone separates the Surficial Aquifer from the Sandstone Aquifer in most of Lee County. It is 0 to 25 feet below NGVD in the central portion of the watershed and the thickness decreases farther south and is absent near Bonita Springs.

The Sandstone Aquifer underlies the upper Hawthorn confining zone throughout nearly the entire watershed. The top of this unit occurs between -21 and -167 feet NGVD in Lee County. In the northern part of the watershed it is between -25 and -50 feet NGVD, but it dips in a southerly direction to -150 feet in the southeastern portion of Lee County and the western portion of Collier County.

The mid-Hawthorn Aquifer of limestones, sandstones, and dolomites also have their structural highs in the northeastern portion of the watershed, and then thin to the southeast around Corkscrew Swamp.

The top of the Floridan Aquifer is associated with the lower Hawthorn Formation and the Tampa Formation. The top of the lower Hawthorn/Tampa Aquifer ranges from -350 feet NGVD in northwestern Lee County to -700 feet NGVD in the southern portion of the county. Thickness varies from 80 to 275 feet and regional highs are located in Cape Coral and east Fort Myers.

Variation in water levels in the watershed are greatest near the coast, where water levels may vary as much as 4 feet between wet and dry seasons near Bonita Springs and variation decreases eastward.

The Tamiami Formation is approximately 150 feet in thickness in Collier County and forms the principal shallow aquifer in the county (SWRPC, 1995). The Floridan Aquifer varies in thickness and underlies all of Collier County. Water from this aquifer is too salty for most purposes and is used as a supplemental supply in irrigation systems. The Hawthorn and Tampa formations overlay the Floridan Aquifer. The Hawthorn ranges from 250 to 300 feet in thickness and lower limestone of this formation are interconnected with the main body of limestones of the Floridan. The Tampa Formation is a sandy limestone with some phosphate associations in Collier County. This formation is the chief source of water yielded by flowing wells penetrating the upper part of the Floridan Aquifer.

In Lee County, the Tamiami and Hawthorn formations occur approximately 40-580 feet in thickness. These formations occur as limestones and dolomites and serve as reservoirs for the Tamiami and upper Hawthorn aquifers which supply freshwater. The lower Hawthorn Aquifer water supply is highly saline. The Suwannee Limestone contains saline water. No aquifers in the Ocala Group have been penetrated in Lee County (SWRPC, 1995).

2.3 Soils

The characteristics of the soils of the study area are discussed by soil category in the following sections.

Holocene sediments in the watershed are products of a abundant seasonal rainfall and subtropical climate. Much of the "soils" in the watershed, rather than layers of mixed mineral and organic materials, represent only slightly weathered parent material, or modern sediments, some of which are still being formed. The soils are generally described as surficial sediments.

The soil types in the watershed include limestone rock, calcareous muds (marls), sands (marine terraces), organic materials (peats and muck), and mixed solids (Duever et al., 1979; SFWMD, 1980). The absence of either updated (e.g., Collier County) or completed soil surveys also prevents a watershed or region-wide application of the SCS soils series (Duever et al., 1979; Carlisle and Brown, 1982).

An additional substrate is made up of anthropogenically altered or arent soils, e.g., dredge and fill, shell mounds, and landfills (Herwitz, 1977). Examples are the inland and coastal artificially constructed canals. Modification of natural tidal tributaries to finger canals is prevalent in developments, and there is a shift away from autochthonous sediment production in the natural waterways to a primarily allochthonous source of sediments in the canal system. Marls and sand marls generally range from 6 inches to 3 feet in depth, have low relief, and because of low water permeability, are often wet (SWFMD, 1980). Marl soils account for almost 400 acres (29%) of the soils surveyed in Collier County (Leighty et al., 1954).

Sands are the dominant surficial soil in the watershed. They are derived from old shoreline deposits, weathered limestone, and movement of sands by wind and water. Deposits are generally thicker and more extensive north and west of Big Cypress Swamp.

Marine quartz sands dominate the surficial deposits from mid-Collier County to the norther reaches of the Caloosahatchee River (White, 1970). The Immokalee Rise is composed of sands in the form of relict bars and swales, which decrease in thickness to the south, east, and west, and eventually grading into Big Cypress Swamp to the east (Duever et al., 1979). Greater detail of the physical and chemical nature of the soils in the watershed are published by the USCS for Lee, Collier, and Hendry counties.

The major surface peat deposits in the watershed are located along the southwest coat from Gordon Pass south, in the Corkscrew Swamp near Lake Trafford (Leighty et al., 1954). Smaller peat deposits occur in other swamps, marshes, ponds, and sloughs. Compared with peats of the Everglades, swamp peats of the Corkscrew Swamp are more degraded and mucky, with less conspicuous plant tissues. The condition may suggest a shorter hydroperiod, or deeper aeration zone (Stone and Gleason, 1976).

Approximately 60% of the soils in Lee County are coastal and interior flatwoods and sloughs soils of the Hallandale-Boca and Isles-Boca-Pompano complex. They are nearly level, poorly drained, sandy soils with loamy subsoil. The remaining soils are Wulfert-Kesson-Captiva and Peckish-Estero-Isles soils of tidal areas and barrier islands which are poorly drained, sandy and mucky soils.

Much of the description of the soils of the Estero Bay Watershed was summarized from the County Soil Surveys for Lee, Hendry, and Collier counties. Each individual soil can be classified into a hydrologic soil group (HSG) based on its runoff producing characteristics. The most important of these characteristics is the inherent capacity of the soil to permit infiltration when bare of vegetation.

The four major hydrologic soil groups are:

- **Group A** (low runoff potential) - soils with high infiltration rates even when thoroughly wetted. Composed primarily of sands and gravel that are deep and well to excessively drained. These soils have a high rate of water transmission. Minimum infiltration rate = 0.30-0.45 in/hr.

- **Group B** (low to moderate runoff potential) - soils with moderate infiltration rates when thoroughly wetted. The soils are typically moderately fine to moderately coarse in texture and have a moderate rate of water transmission. Minimum infiltration rate = 0.15-0.30 in/hr.

- **Group C** (moderate to high runoff potential) - soils with slow infiltration rates when thoroughly wetted, often with a layer of soil that impedes the downward movement of water. The soils typically have a moderately fine to fine texture and a slow rate of water transmission. Minimum infiltration rate = 0.05-0.15 in/hr.

- **Group D** (high runoff potential) - soils with very slow infiltration rates when thoroughly wetted. Primarily clay soils with a high permanent water table or shallow soils over nearly impervious materials, such as a clay pan or clay layer. These soils have a very slow rate of water transmission. Minimum infiltration rate = 0.0-0.05 in/hr.

An individual soil parcel can be assigned to two soil groups (e.g., A/D) if part of the area is artificially drained and another part is undrained. The distribution of hydrologic soil groups for the study area (U.S. Department of Agriculture, Soil Conservation Service) is mapped in Plate 2-3. Less than five percent of the soils in the watershed (Table 2-1) are classified as very well-drained, well drained, to less well-drained (HSG designations A, B, and C), while 95% are classified as D (poorly drained).

Table 2-1. Hydrologic soil types in the Estero Bay Watershed.

HYDROLOGIC SOIL GROUP	ACRES	PERCENT
A	2,015	1%
B	846	<1%
C	9,578	3%
D	263,507	95%
TOTAL	186,161	100%

2.4 Rainfall

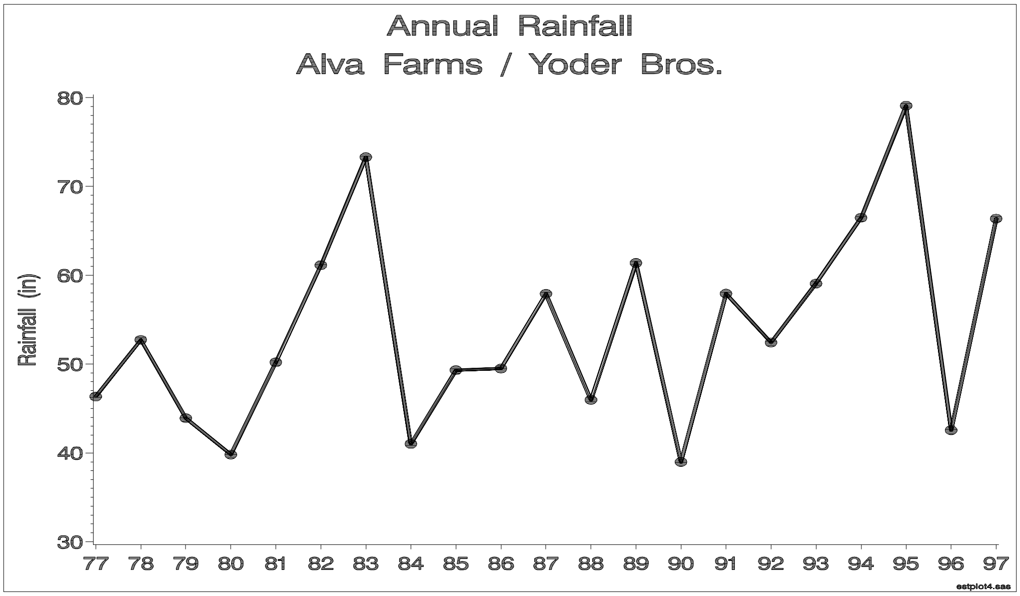
The purpose of this section is to examine spatial and temporal trends in rainfall at a variety of sites within the Estero Bay Watershed.

The Estero Bay Watershed lies in the temperate zone but the climate is greatly modified by sub-tropical influences of the Atlantic Ocean. Episodes of intense rainfall are generally associated with hurricane activity in the basin and the greater portion of rainfall occurs during seasonally as intense local convective storms (Pratt, 1980). Hurricanes are most likely to occur in August, September, or October. Rain storms seldom exceed six hours duration and the greatest amounts of rainfall generally occur within the first three hours of the storm.

There are numerous rainfall monitoring sites within the general area surrounding the Estero Bay Watershed (Plate 2-4). Many of the sites had incomplete records or had relatively short periods of record. Data from six rainfall stations with monthly data from 1977 through 1997 were plotted to examine possible long-term and seasonal trends in rainfall in the watershed. Total annual precipitation in the Estero Bay Watershed ranged from approximately 32 inches of rain in 1987 to 80 inches of rain in 1995 (Figures 2-1 through 2-6). Peak annual precipitation ranged from 70 inches to 80 inches and occurred most notably during 1982, 1987, 1991, and 1995 in nearly all cases. Low yearly rainfall occurred during 1980, 1981, 1985, 1990, and 1996 for most stations and precipitation was generally at or below 40 inches during these years.

No clear spatial patterns are evident from the rainfall data examined. Variability among rainfall stations was apparent but no area of the watershed appeared to receive more rainfall than any other within the watershed.

Average monthly precipitation was highest for the summer months and lowest in the winter for all the basins (Figures 2-1 through 2-6). More than 60% of the annual mean rainfall occurs from June through September in the watershed (Howard et al., 1977). Monthly precipitation was highest from June to September, and wet season average values ranged from 7.4 inches in September to more than 9 inches in June. Average monthly rainfall values in the watershed were lowest during November and typically ranged from 2 - 3 inches of rain and generally did not exceed 4 inches from October through May.



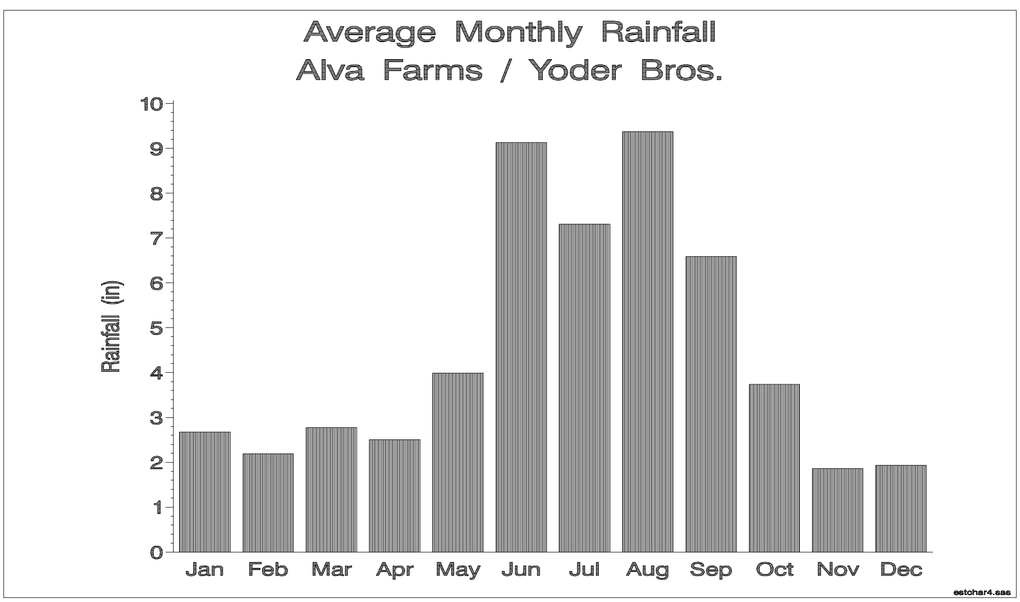
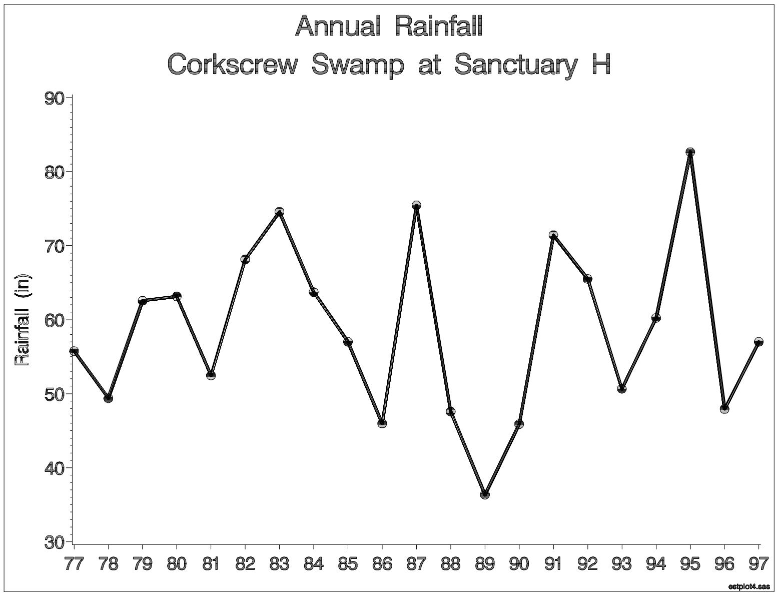


Figure 2-1. Annual (top panel) and average monthly (bottom panel) rainfall at Alva Station**.**



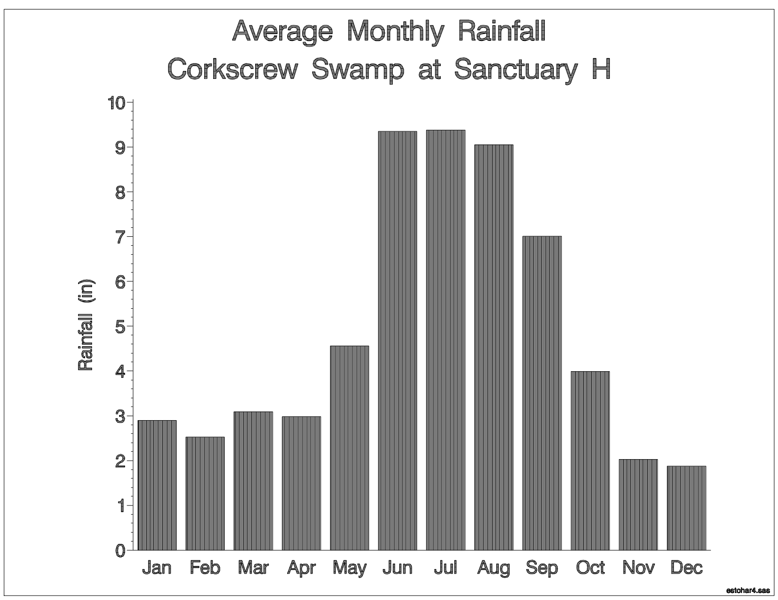


Figure 2-2. Annual (top panel) and average monthly (bottom panel) rainfall at Corkscrew Station.

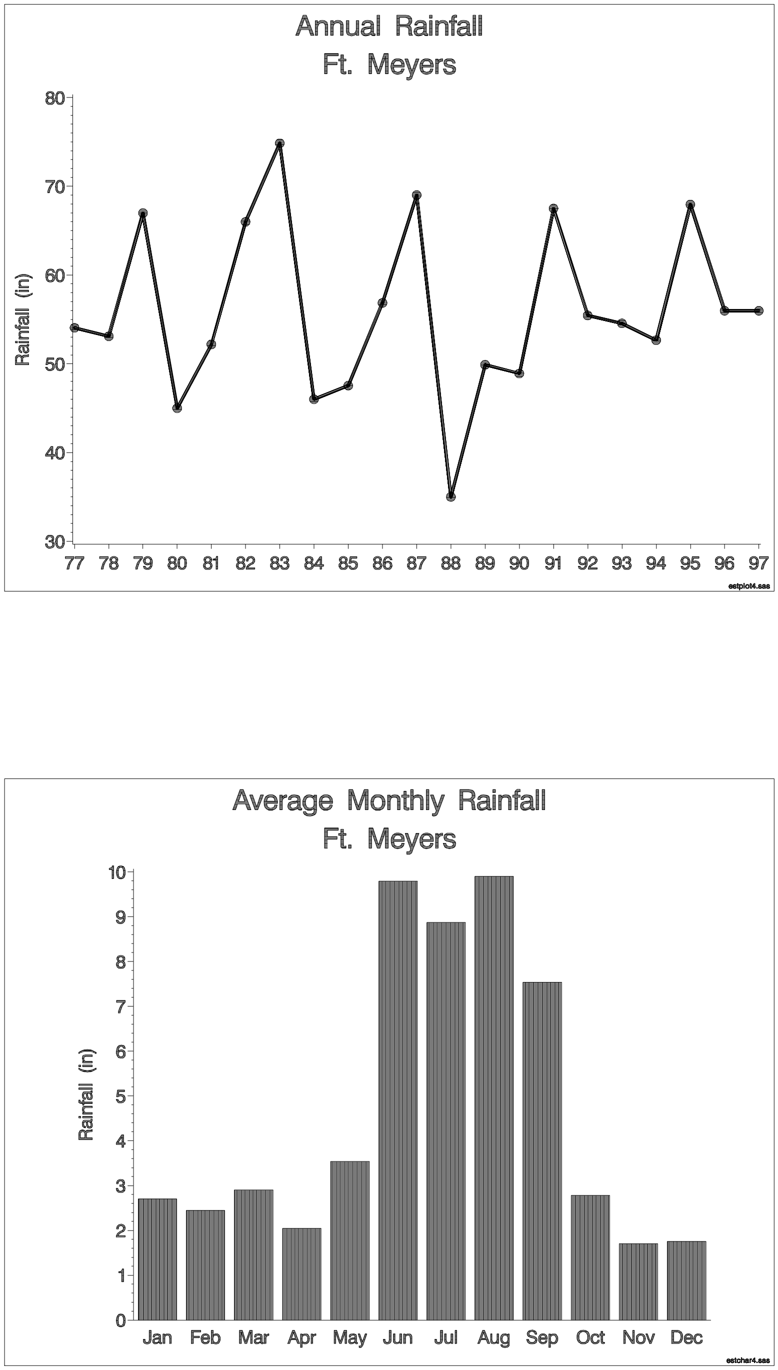
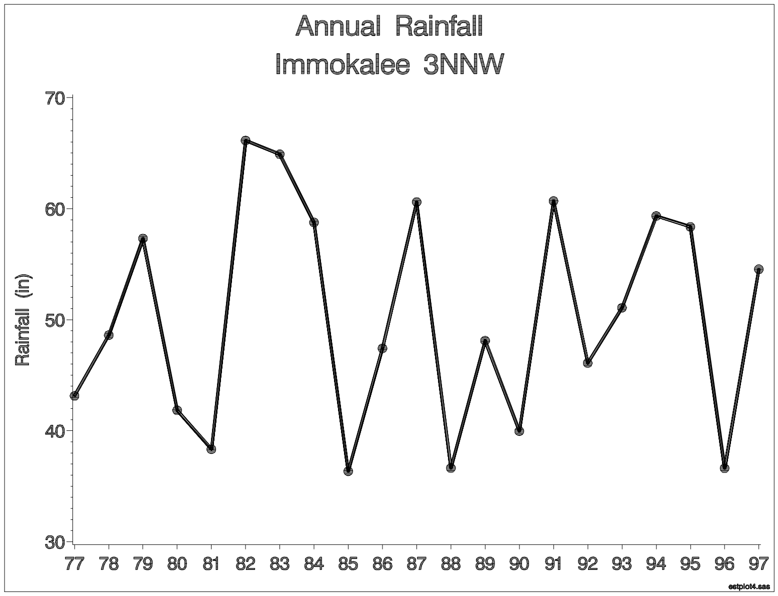


Figure 2-3. Annual (top panel) and average monthly (bottom panel) rainfall at Ft. Myers Station.



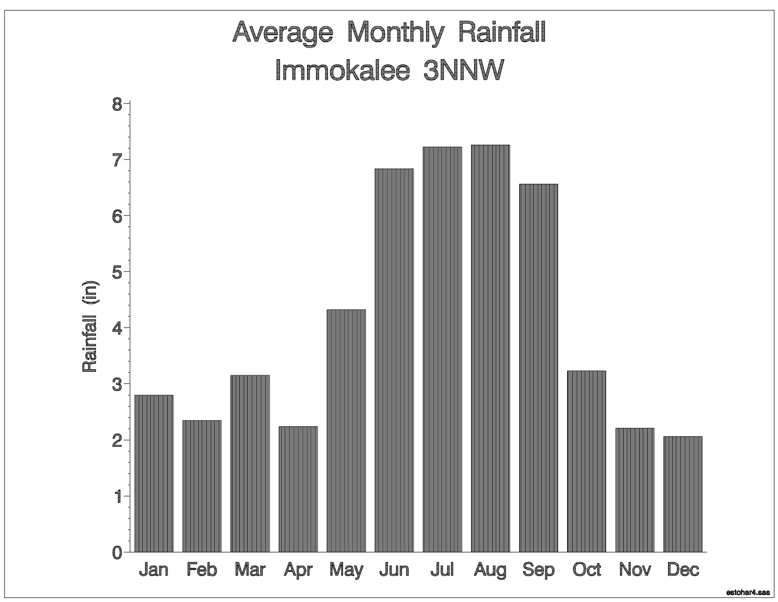
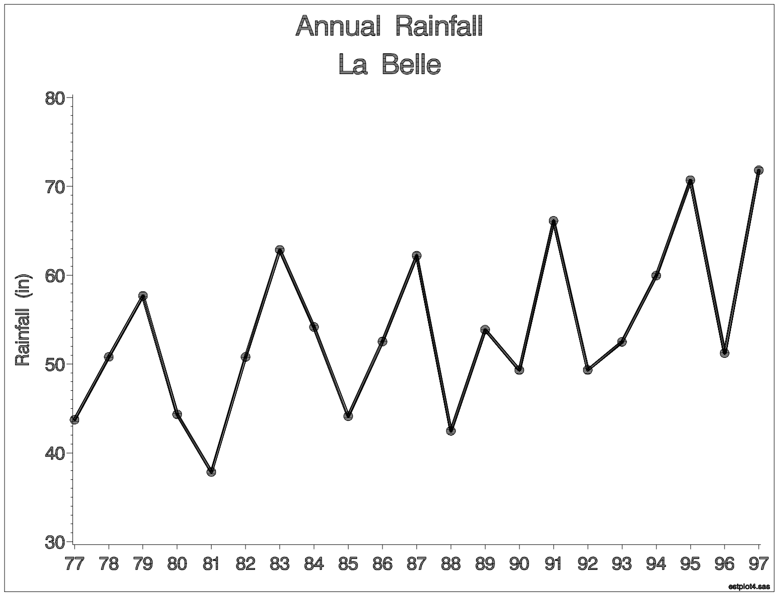


Figure 2-4. Annual (top panel) and average monthly (bottom panel) rainfall at Immokalee Station.



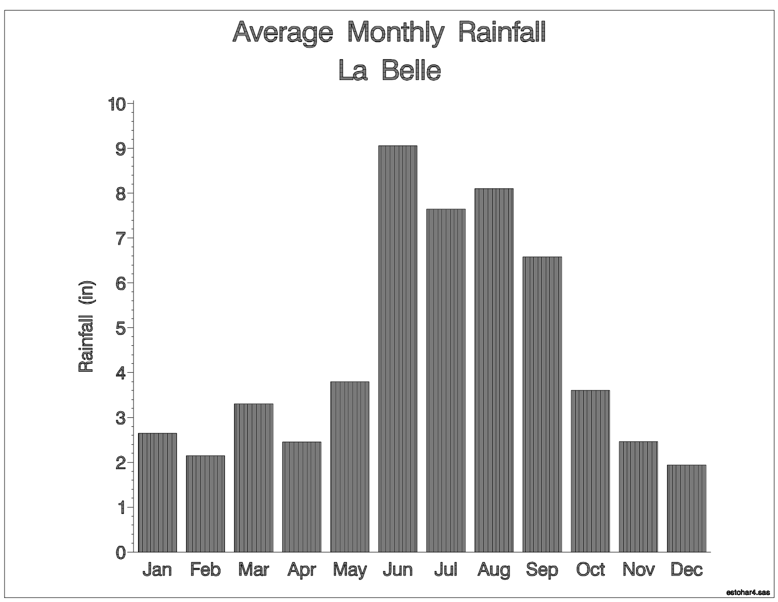


Figure 2-5. Annual (top panel) and average monthly (bottom panel) rainfall at the LaBelle station.

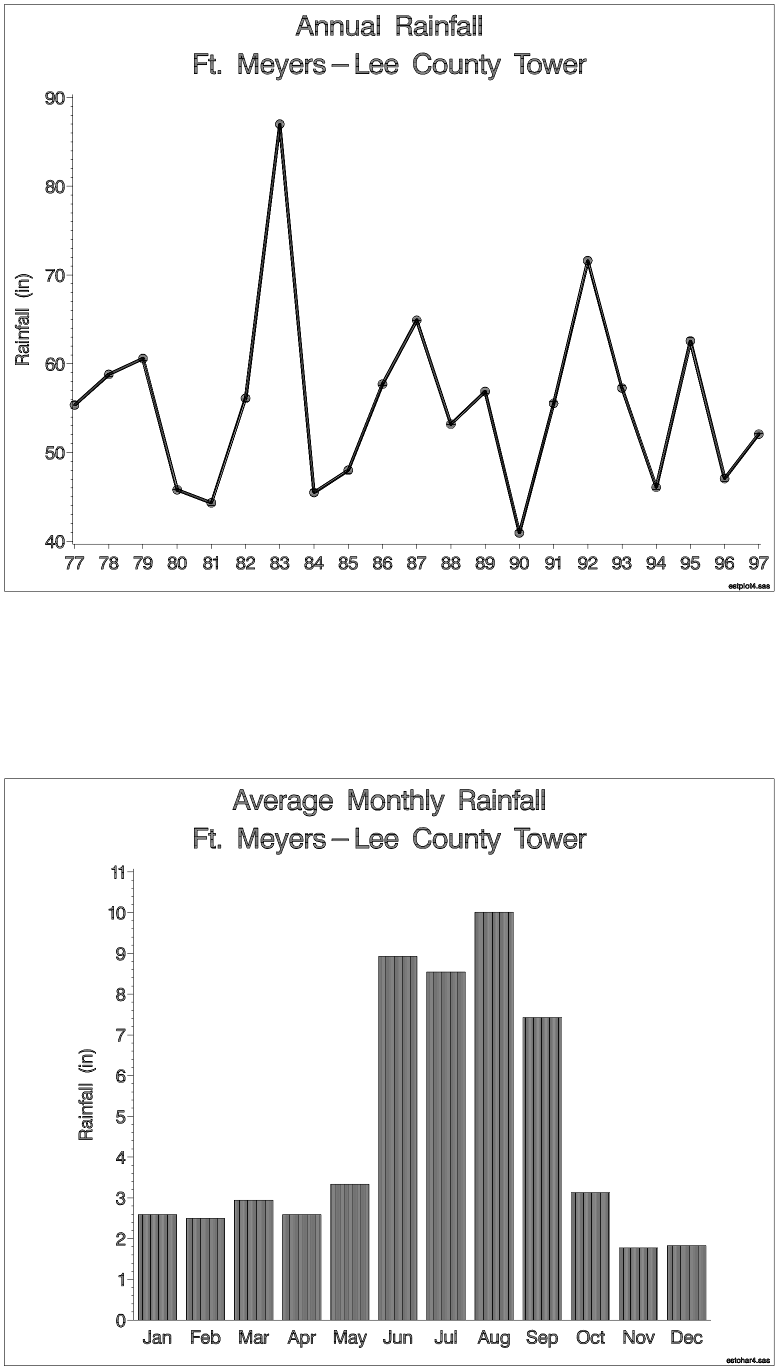


Figure 2-6. Annual (top panel) and average monthly (bottom panel) rainfall at the Lee County rainfall station.

2.5 Existing and Future Land Use

Existing land use acreages for the Estero Bay Watershed are presented in Table 2-2 and future land use acreages are presented in Table 2-3. Existing and future land use maps are presented in Plates 2-5 through 2-8.

The existing land use/cover data for the Estero Bay Watershed presented in this document are from the 1995 District land use data. SFWMD land use data are based on the Florida Department of Transportation (FDOT) “Florida Land Use and Cover Classification System” (FLUCCS).

Future land use coverages for the Estero Bay Watershed were developed by Southwest Florida Regional Planning Council (SWFRPC). SWFRPC obtained future land use maps from all RPCs in the state, and digitized the maps to develop a state-wide coverage. The future land use maps (FLUMs) are general and intended to guide future growth. They are not based on present conditions, nor do they recognize many features that will probably be present in the future (such as smaller wetlands). Importantly, FLUMs provide a 100% build-out scenario which does not take into account areas which will not be developed as result of land use regulations and restrictions.

The FLUMs use a different, and much simpler, land use classification system than either of the existing land use coverages and do not identify existing developed urban land use or land cover. A geographic area designated for future residential growth on the FLUMs might encompass existing commercial, institutional, or wetland areas (Rains et al., 1993). As a result, residential areas may increase tremendously under future scenarios because existing development is not taken into account. Direct comparisons between acreages of a particular type of land use for existing and future conditions cannot be made without evaluating the criteria used to develop that land use category.

2.5.1 Existing Land Use

Existing land use in the Estero Bay Watershed was mapped to provide an overview of the basin land use (Plate 2-5). FLUCCS Level II land use classifications are also mapped for developed (agriculture and urban land uses) and undeveloped (natural and undeveloped land uses) (Plates 2-6 and 2-7) as a means of examining land use more closely for undeveloped and developed lands.

Developed land uses in the Estero Bay Watershed are concentrated between S.R. 41 and I-75 throughout the basin. In the southernmost portion of the basin, along Spring Creek and the Imperial River, residential communities such as Bonita Bay, Bonita Springs, and Bonita Shore expand east along Bonita Beach Drive and across the bay to barrier islands. In the northern portion of the watershed, highly developed areas include Estero Island and areas adjacent to Cape Coral and Fort Myers.

Residential land use alone makes up about 8% of the land use in the Estero Bay Watershed and total urban land use (residential, commercial, industrial) makes up about 11% of the acreage in the basin (Table 2-2). Twenty-six percent of the basin area is in agriculture. The combined total for urban and agricultural developed land use is 44%, while the remaining 56% is undeveloped and includes predominantly freshwater wetlands (34%) and upland forests (16%). Water comprises 6% of the total watershed area (292,286 acres).

Urban land use in the watershed is primarily located in the western developed corridor, the areas around Florida Gulf Coast University, Bonita Springs, and west Immokalee. Natural areas, including major wetland and associated upland systems are located in the central and eastern parts of the basin, while agricultural uses occur along the boundaries and between the large wetland systems.

The current land use plan of Lee County classifies the entire Estero River corridor east of Koreshan State Historic Site as “Urban Community/Suburban.” The area immediately west of the state historic site is classified as “Outlying Suburban.” The state historic site and the area surrounding the mouth of the river are classified as “Resource Protection Zones.” Estero Bay is a designated Aquatic Preserve and an Outstanding Florida Water. The Estero River is a designated Recreational Canoe Trail. In addition to the public land associated with the historic site, much of the land surrounding Estero Bay and extending south for approximately two miles has been purchased by the State of Florida under the Conservation and Recreation Lands (CARL) program to maintain the pristine nature of the environment.

Conservation 2020 is an initiative endorsed by Lee County voters in 1996, Conservation 2020 is a property tax supported environmental land acquisition program administered by the Lee County Commission, with a 15 member steering committee making recommendations on the priority of purchases over the next seven years.

Preservation 2000 was established by the Florida Legislature and is an environmental funding source for acquisition programs such as the state agencies combined Conservation and Recreational Lands (CARL) program, the Save Our Rivers (SOR) initiative of FDEP and the Water Management Districts, and the acquisition programs of DCA and GFWFC. P-2000 and the related programs have been requested to fund some of the sensitive land purchases in the basin.

Table 2-2. Land use/cover in the Estero Bay Watershed.

LAND USE CLASS	AREA (acres)	PERCENT COVER
Developed - Urban		
Residential	23,342	8
Commercial/Industrial	3,663	1

Table 2-2. Land use/cover in the Estero Bay Watershed.		
LAND USE CLASS	**AREA (acres)**	**PERCENT COVER**
Extractive	2,453	1
Institutional	389	0
Recreational	3,913	1
Open Land	4,926	2
Barren Lands/ Disturbed	5,770	2
Transportation/ Utilities	5,775	2
Developed - Agriculture		
Agriculture	77,157	26
Shrub/Brushland	4086	1
Undeveloped - Natural		
Upland Forested	46,038	16
Wetlands	98,557	34
Water	16,199	6
Total	**292,286**	**100**

2.5.2 Future Land Use

Future land use maps from the SWFRPC for the Estero Bay Watershed (Plate 2-8) predict increases in urban land use from less than 20% in 1995 to more than 40% in the year 2000. Predicted increases in agricultural land use are minimal.

Table 2-3. Future (2010) land use/cover in the Estero Bay Watershed.		
LAND USE/COVER	**AREA (acres)**	**PERCENT COVER**
Single Family Residential	58,555	31%
Multi-family Residential	965	1%
Rural Residential	11,512	6%
Commercial	7,521	4%
Industrial	14,419	8%

Table 2-3. Future (2010) land use/cover in the Estero Bay Watershed.		
LAND USE/COVER	**AREA (acres)**	**PERCENT COVER**
Agricultural	52,847	28%
Protected Resource	43,503	23%
TOTAL	189,492	100%

2.6 Surface Water Hydrology and Water Management Practices

There are no streamflow gages located in the Estero Bay Watershed. Freshwater inflow into the Estero Bay estuary generally peaks in September (Drew and Schomer, 1984). Flows measured in the Imperial River from 1940 to 1952 indicate that flow in dry months (December to May) averages only about 7% of the total annual inflow. Tidally-induced flows in Estero Bay are far greater than freshwater inflow. Freshwater inflow into Estero Bay is low and upper reach salinities seldom fall below 10 ppt in the wet season.

The surface water hydrology of the Estero Bay Watershed is presented in Plate 2-9. There are only minor creeks and rivers flowing into Estero Bay providing a source of fresh water, making Estero Bay extremely sensitive to changes in upland drainage, thereby affecting the quantity, quality, and seasonality of freshwater influx. Much of the area is subject to flooding during periods of extensive rainfall (SFWMD, 1980). During low flow conditions, such as droughts, most of these coastal streams have negligible freshwater discharge. Along the mainland of Estero Bay, most stormwater either evaporates or empties into the streams and canals that discharge into the bay. Coastal streams are relatively short (less than 8 miles long) and sluggish due to low gradients, with flows ranging from 1 to 3 feet per minute (Lee County, 1997).

While historically the rivers in the Estero Bay Watershed had extensive marsh or mangrove fringes, some of these have been lost to development (Sutcliffe and Thompson, 1983). The increasing development of greater Ft. Myers to the north relies on drainage canals that eventually flow to the bay and urbanization of the area is creating surface water management problems (Lee County, 1997). Some shallow agricultural channels also convey surface water runoff. The fresh water discharges combined with tides influences circulation patterns, sedimentation, and pollutant levels.

Because of the level topography (average slope = 0.035%; JEI, 1998), the surface drainage patterns to Estero Bay are poorly defined, with significant numbers of wetlands and relatively short, low gradient freshwater tributary streams, and surface water hydrology is influenced by overland sheetflow. Surface water from the Six-Mile Cypress Slough, which serves as the outfall channel for the Six- Mile basin, intercepts Ten-Mile Canal north of U.S. Highway 41. Surface water runoff from both the Ten- and Six- Mile basins are channeled down Ten-Mile Canal to Mullock Creek and eventually into Estero Bay (SFWMD, 1980).

Historic subbasin boundaries vary in the literature, depending on the data used. Average rainfall conditions do not result in the same sheetflow patterns as high rainfall conditions and development has also altered the boundaries by diverting flows. Historic sheetflow patterns are illustrated in Figure 2-7.

As sheetflow moves southwest across the basin, it is collected by natural and artificially constructed channels and conveyed into the Estero River, Halfway Creek, Spring Creek, the Imperial River, Cocohatchee River, Corkscrew Canal, and Camp Keais Strand. Much of the sheetflow of water from northeast to southwest in the basin has been obstructed by a series of elevated grades and dikes in the interstate area between Corkscrew Road on the north and County Road 846 on the south (JEI, 1998). During high rainfall events much of the flow of water spills over to the western portion of the basin into the Imperial River rather than flowing southwest to the Cocohatchee River (Figure 2-8). As a result, the Estero River, Halfway Creek, Spring Creek and Imperial River cannot accommodate the runoff generated from the upstream Corkscrew Swamp area, and low-lying areas in southwest Lee County are inundated by stormwater runoff generated miles away.

The cumulative effects of these hydrologic alterations have led to lower dry season water tables, point discharges of runoff rather than sheetflow, decreases in stage and timing of wetland inundation. For example, a mass balance calculation of rainfall vs. outflow of the Imperial River during the 1995 flood indicated that more water was discharged from the Imperial River than had actually fallen in the 86 square mile watershed (JEI, 1998).

2.7 Development Patterns

Land uses in the Estero Bay Watershed have changed significantly over the past century (State of the Bay Report, 1998). Spanning three counties, the watershed covers all of southern Lee County, the northwestern portion of Collier County and the southwestern tip of Hendry County and includes the Flint Pen Strand, the Corkscrew Swamp Sanctuary, and Lake Trafford. The most dramatic of these changes in land uses have dealt mainly with the reduction in wetlands, the increases and then the decreases in agricultural areas, and the continued increasing of urbanization in a six to eight mile wide corridor between the Bay on the west and I-75 to the east.

In 1900, very little of the lands in the watershed had been impacted by modern man. Other than small communities on the shores of the Estero and Imperial rivers, the land uses in the watershed remained undeveloped and used mostly as open range for cattle production, timbering and hunting. The entire area was viewed by those not living here as a hot, swampy land that was not fit for human

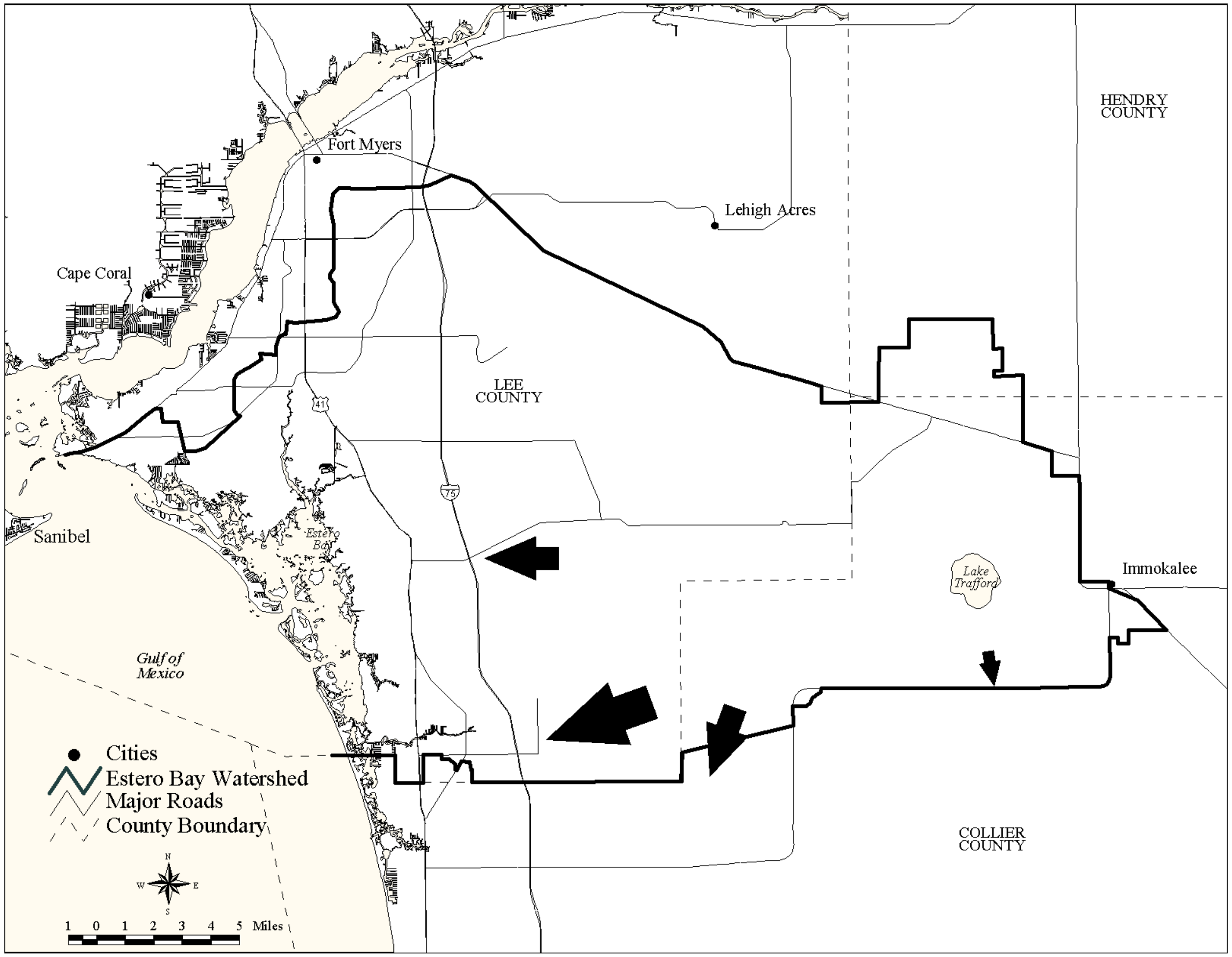


Figure 2-7. Historic sheetwater flows in the Estero Bay Watershed.

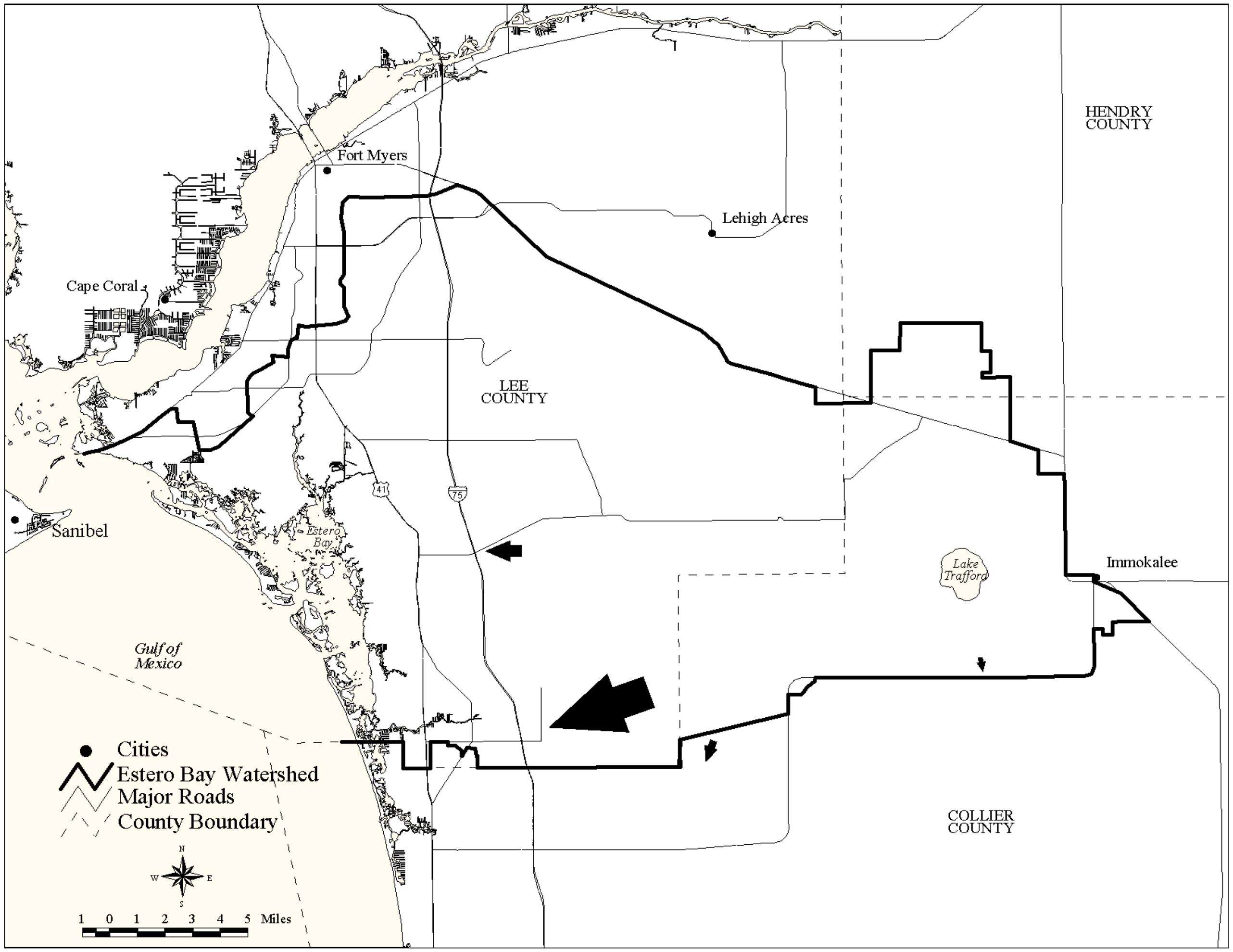


Figure 2-8. Existing sheetwater flows in the Estero Bay Watershed.

habitation. A benefit coming from this point of view was that the uplands and wetlands remained and functioned together balancing the stormwater runoff and nutrient loading entering the bay system, thereby keeping the bay healthy and viable and retaining the majority of the native habitats, keeping the basin's wildlife plentiful.

Following World War II, many of the servicemen who trained on bases throughout south Florida and experienced the region's environment either immediately returned to the area with their families after the war or after working in other areas of the country, began retiring to this area. This trend invited a population influx beginning in the 1960s and 1970s. This population increase caused land uses in the western corridor of the watershed, which included the San Carlos Park, Estero, San Carlos Estates, Estero Bay Shores/Spring Creek Village, Bonita Springs, Bonita Beach, and Immokalee communities, to grow. Additionally, agricultural demands for a growing population increased the demand for agricultural land uses.

These increases in human activities on the land, substantially changed the watershed's land use patterns. The changes to the stormwater runoff and nutrient loading patterns into the bay and the changes which reduced the wilderness habitat necessary for the large variety of plants and animals in the watershed substantially impacted the bay and the natural upland areas in the basin. In response to these land use changes not only in the Estero Bay Watershed but throughout Florida, the state, regional, and local governments adopted plans to provide guidance for the future land use changes. Because of the governmental regulatory activities, the development reviews increased and land uses were limited via the comprehensive plans. As a result, the major wetland systems in the watershed remained even though somewhat reduced in size and development densities in the center of the watershed were reduced.

During the 1980s, the population increase had not abated. Demand for the southwest Florida lifestyle, the livability of the environment, the increased use of air conditioning and the control of mosquitoes, which in a large part has been due to the on-going development, kept the land use conversions on-going. In the mid-1980s, the growth impacted counties containing the basin amended their comprehensive plans in an attempt to control the location and intensity of the urban land use changes. While the comprehensive plans forced the urban growth to take place mostly in the western portion of the watershed, and protected the major wetland systems in 1900, most are now identified, and protected through ACOE, SFWMD, and county regulations. The adjacent upland areas located around the wetlands are being utilized mostly for agricultural purposes. Land uses in these areas are now severely restricted by the County's comprehensive plan to low density residential and agricultural uses.

In 1997, the general land use pattern in the Estero Bay Watershed seems relatively set with urbanized land use patterns located in the western developed corridor, the areas around the university, Bonita Springs, and western Immokalee. The major wetland and associated upland systems are firmly set in the center and eastern parts of the watershed; and the agricultural uses are located on the boundaries and between the large wetland systems. The change at this time would appear to be the implementation of increased governmental acquisition and management of sensitive lands around the wetland systems that remain. This will be difficult with the increased agricultural interest in the area. However, recently there seems to have been fewer requests for land use amendments to the areas identified for future preservation in the central portion of the basin and continued public support for the acquisition of sensitive lands for preservation is being addressed via the CREW, Preservation 2020, and other like programs.

Changes in land uses that have taken place within the Estero Bay Watershed during the past century are mapped in Plate 2-10 (after Everglades Systems Research Division, 1994). The maps provide an interpretation of the land uses as they existed c. 1900, c. 1970 and in 1997. As the various map legends indicate, human activity has created an ever increasing diversification of land covers and thereby has created evermore complicated classification systems to identify these uses. The 1997 map reflects the most detailed categorization and has added the most recent land use classifications associated with large scale master planned communities. It should be noted that these maps are prepared at a regional scale with generic information available from public sources, and as such, should not be construed to be site specific determinations as to exact boundaries of the various land uses in the watershed.

Development and DRIs

Most development in the Estero Bay Watershed has occurred along the coastal areas west of I-75 and most DRIs are also located west of I-75. However, the largest DRIs, Alico, Inc. in the Estero River Basin and Westinghouse Gateway in the Six-Mile Cypress Slough Basin, are east of I-75 in the northern-most portion of the watershed (Plate 2-11).

Fifty-two DRIs are located in the Estero Bay Watershed, and are listed by secondary basin in Table 2-4. Of these 52 DRIs, Six-Mile Cypress Slough, Hendry Creek, and Estero River basins include 33 different DRIs, 14 of which are in Six-Mile Cypress Slough. Nine of these are located in Tertiary Basin 4 which is bounded by I-75 to the west, S.R. 82 to the north and east, and Alico Road to the south. Although there are ten DRIs in Hendry Creek, they are all relatively small.

Table 2-4. DRIs within the Estero Bay Watershed.

DRIs	SECONDARY BASIN	TERTIARY BASIN	TYPE	AREA (acres)
65 - Metro Park	1	11	Multi-use	240
118 - Tamalico Court	2	1	Commercial/Industrial	90
95 - Danport Center	2	3	Multi-use	259

Table 2-4. DRIs within the Estero Bay Watershed.

DRIs	SECONDARY BASIN	TERTIARY BASIN	TYPE	AREA (acres)
23 - Southwest Florida International Airport	2	4	Regional airport	11,827
53 - Gateway Community	2	4	Multi-use	5,464
96 - Airside Plaza	2	4	Multi-use	126
112 - Southwest Florida International Airport Substantial Deviation	2	4	Regional airport	11,827
86 - Omni Interstate Park	2	4	Multi-use	922
21 - The Estuaries	3 6 6 6 7 7 7	1 5 6 7 1 2 3	Residential	6,500
31 - Three Oaks	3 4	4 8	Multi-use	495
137 - Pelican Landing/Spring Creek West	4 8 8 8 11	3 1 3 4 1	Residential/Multi-use	2,383
57 - Corkscrew Pines	4	6	Multi-use	904
149 - The Brooks of Bonita Springs	4 8	6 7	Mixed Use/Residential	2,492
63 - Timberland and Tiburon	4	8	Multi-use	795
124 - Alico Inc. AMDA	4	8	Multi-use	11,000
150 - Timberland and Tiburon Substantial Deviation	4	8	Multi-use	795
158 - Miromar Lakes	4	8	Residential/Mixed Use	1,323
34 - Bonita Bay	5 8 8 8	1 1 2 5	Multi-use	2,424

Table 2-4. DRIs within the Estero Bay Watershed.

DRIs	SECONDARY BASIN	TERTIARY BASIN	TYPE	AREA (acres)
72 - Springs Plaza Expansion	5	1	Multi-use	86
90 - Woods Edge	5	1	Multi-use	114
113 - Bonita Grande R.V. Resort	5	4	Recreational Vehicle Park	403
54 - The Habitat	5	6	Multi-use	1,003
60 - The Parklands	5	6	Multi-use	996
98 - Parklands West	5	6	Multi-use	324
121 - Collier Preserve	6 6 6 6 6 7 7 7	1 2 3 4 5 1 2 3	Multi-use	506
69 - Boardwalk Caper	6	4	Multi-use	33
39 - The Forest and The Oaks	7 7	4 6	Multi-use	625
79 - Healthpark Florida	7 7	5 8	Multi-use	403
38 - Parker Lakes	7	8	Multi-use	240
11 - Cypress Lakes Land	7	10	Residential	380
14 - Villas South	7	10	Multi-use	80
62 - Cypress Trace Shopping Center	7	10	Commercial	53
64 - Cypress Lake Center	7	10	Multi-use	69
77- Leisure Village at 7 Lakes Expansion	7	10	Multi-use	211
123 - Market Square	7	10	Commercial	56
25 - Spring Creek East	8 8	5 6	Multi-use	278

Table 2-4. DRIs within the Estero Bay Watershed.				
DRIs	**SECONDARY BASIN**	**TERTIARY BASIN**	**TYPE**	**AREA (acres)**
140 - Bay Beach Docks	**11**	**1**	**Wet Slips**	**-**

Agriculture, ranching, row crops, and citrus.

Cattle ranching is probably the oldest type of agriculture in the basin and cattle once grazed the entire area unhampered at first by any fencing and with little supervision other than roundups and cattle drives to market. More recently cattle ranching has become more intense with planted grass and selected breeds that deal with our climate more efficiently.

Row crop farmers are attracted to south Florida mainly because of the mild winter temperatures. This industry has made phenomenal growth in the past few years, having an advantage of growing vegetables in the off-season from the rest of the continental United States. The advent of refrigerated transportation has greatly advanced the growth of this industry. Global economics and international trade have somewhat impacted the row crops the last few years. Sugar cane growing, mostly on the heavy muck soils around Lake Okeechobee, has long been one of the biggest suppliers of revenue in the entire area of south Florida.

Citrus has been grown on the banks of the Caloosahatchee River for many years. However, the large plantings in this area of Florida are more recent, following the devastating freezes in central Florida starting some 30 years ago. This has been the fastest growing agricultural enterprise in southwest Florida in the past few years, with processing plants and fresh fruit packing facilities being built in this area. Due to the plantings of the last decade this southwest segment of Florida will be the largest citrus growing area in Florida. Global economics have also affected this agricultural commodity.

2.8 Research Activities

Research activities in the Estero Bay Watershed include the Lake Trafford Restoration Project . The project is sponsored by the Florida Department of Environmental Protection (FDEP) and the Florida Game and Freshwater Fish Commission and implementation is the responsibility of the USACE. Lake Trafford is located approximately 3 miles west of Immokalee, in north Collier county and is the largest lake south of Lake Okeechobee in Florida. The lake forms the headwaters of the Corkscrew Swamp sanctuary to the southwest, the CREW to the west, and the Fakahatchee Strand system, which includes the Florida Panther National Wildlife Refuge, to the south. In addition, the water quality of the lake and associated watershed affects important wildlife species and offers a sanctuary for migrating birds.

The Florida Panther is an endangered species elevated to the forefront of public awareness due to its decline in population due to habitat loss. Presently, there are only an estimated 30 to 50 animals remaining in the wild in south Florida. The presence of Florida Panthers was recorded soon after Hernando DeSoto landed in Tampa Bay in 1539. However, hunting pressure along with habitat loss from the expanding Florida population over the past centuries are largely responsible for decline in the panther population. Further decline in the population has occurred as a result of decline through genetic defects from inbreeding, mercury poisoning through the food chain, and pressure from human expansion. Habitat preservation is the only means of preserving the Florida Panther in the wild.

Florida Panthers are solitary with a relatively large home range, which makes maintaining adequate size habitats a challenge. Panther habitat consists of large expanses of mixed cypress swamp, hardwood swamp, pry prairie and pineland. A male panther home range averages 275 square miles and usually overlaps with smaller ranges of females with whom they periodically mate.

In south Florida, panthers have been found in most types of vegetation including tropical hammocks, pine flatwoods, cabbage palm forests, mixed swamp, cypress swamp, live-oak hammocks, saw grass marshes, and Brazilian pepper thickets. Open agricultural lands are common around most publicly owned land in southern Florida and receive some use by panthers if cover nearby is adequate.
The fragmentation of native forests may have reduced suitability of many areas for panther habitat.

Through the use of road kills, panther signs verified by wildlife biologists, and radiotelemetry, the primary public tracts of land that support the remaining breeding population appears to be the Everglades National Park, Big Cypress National Preserve, Fakahatchee Strand State Preserve, Big Cypress Seminole Indian Reservation, and the Florida Panther National Wildlife Refuge. The Charlotte Harbor NEP area abuts these lands to the north, and can be expected to support a panther population, especially in the southern basins such as the Estero Bay Basin.